POLICY: CLIMATE

The Kyoto Negotiations on Climate Change: A Science Perspective

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The Third Conference of Parties to the Framework Convention on Climate Change in Kyoto has just been completed. I present here my analysis of the agreements that were reached in light of the assessments of the climate change issue by the Intergovernmental Panel on Climate Change (IPCC).

Scientific issues were not much discussed in Kyoto. I addressed the conference on the first day, an IPCC press conference was arranged, and the new IPCC chairman, Dr. Robert Watson, addressed the conference during the ministerial segment. The IPCC reports (*1*) were used by the delegates during their preparations for the Kyoto conference as the most authoritative analysis of climate change.

Instead, political and technical issues were in focus. Countries' delegates positioned themselves with regard to future commitments, which were included in a protocol that was finally signed by the countries present after intense negotiations. The protocol specifies different goals for Annex I (or developed) and non–Annex I (or developing) countries. The protocol will, however, not enter into force as a legally binding document until 90 days after the date on which at least 55% of the parties of the convention have ratified it. In addition, enough Annex I parties should be included to account for at least 55% of their total CO_2 emissions in 1990. The United States was responsible for ~38% of these emissions, the European Union (EU) for ~22%, and Japan for ~8%. This condition means that the protocol will not enter into force until it has been ratified by a number of the key developed countries.

Targets and Timetables

After long discussions, it was agreed that non–Annex I parties would not take on specific commitments for emission reductions. It was further agreed that a "comprehensive approach" would be adopted, in that all key greenhouse gases not controlled by the Montreal Protocol on the protection of the ozone layer would be included; that is, CO_2, methane, nitrous oxide, hydrofluorocarbons (HFCs), perfluorocarbons (PFCs), and sulfur hexafluoride (SF_6). The increase of CO_2 alone now accounts for about 70% of the total increase of radiative forcing. Few measures to decrease emissions of methane and nitrous oxide are available. The contributions of the HFCs, PFCs, and SF_6 to the enhanced radiative forcing are still only a few percent.

Party	Allowed 1990–2010	Observed 1990–1995
European Union*	**–8%**	**–1%**
Austria	–8	–3
Belgium/Luxembourg	–8	+1
Denmark	–8	+18
Finland	–8	+3
France	–8	–4
Germany	–8	–9
Greece	–8	+7
Ireland	–8	–1
Italy	–8	–1
Netherlands	–8	+7
Portugal	–8	+49
Spain	–8	+14
Sweden	–8	+7
UK and N. Ireland	–8	–4
OECD, except EU	**(–6)**	**+8**
Australia	+8	+8
Canada	–6	+9
Iceland	+10	–4
Japan	–6	+8
New Zealand	0	+16
Norway	+1	+9
Switzerland	–8	–5
United States	–7	+7
Countries in trans.**	**(–1)**	**–29**
Bulgaria	–6	n.a.
Croatia	–5	n.a.
Czech Republic	–8	–23
Estonia	–8	n.a.
Hungary	–6	–15
Latvia	–8	n.a.
Poland	–6	n.a.
Romania	–8	n.a.
Russian Federation	0	n.a.
Slovakia	–8	n.a.
Slovenia	–8	n.a.
Ukraine	0	n.a.
Non–Annex I parties	**–**	**+25**

* Members of the European Union will implement their respective commitments in accordance with the provisions of Article 4 of the Convention.

** Countries that are undergoing the process of transition to a market economy.

Table 1. Commitments to limit or reduce emissions of equivalent CO_2 from 1990 to 2010 by Annex I parties as agreed to at Kyoto, compared with changes in CO_2 emissions from 1990 to 1995 (*1*, *2*). Total emissions are given in Table 2. N.a., not available.

According to the protocol, Annex I parties will take on specific targets, limitations, or reductions of emissions, to be achieved by about 2010. These are given as targets in terms of changes of equivalent CO_2 emissions (Tables 1 and 2). If parties will be able to limit emissions of other greenhouse gases than CO_2, restrictions on the use of fossil fuels will be correspondingly relaxed.

From 1990 to 1995, the EU decreased its CO_2 emissions by about 1%, while the other countries of the Organization for Economic Cooperation and Development (OECD) together increased emissions by about 8% (Table 1). Of these, Australia, Canada, Japan, and the United States all increased their emissions by 7 to 9%. Annex I countries undergoing a transition to a market economy, on the other hand, decreased their emissions by almost 30%. This means that total emissions of CO_2 by all Annex I parties decreased by about 5% from 1990 to 1995.

The targets agreed to in Kyoto for Annex I parties by 2010 add up to a decrease in greenhouse gas emissions by ~5% below 1990 values (in terms of CO_2 equivalents). Although the EU should achieve a further reduction from 1 to 8% below 1990 levels, and the other OECD countries should move from a 7% increase to a 7% reduction, countries in economic transition were allowed to increase their present emissions by 22 to 30%. The Russian Federation and Ukraine were particularly favored; special allowances were given to Australia, Iceland, New Zealand, and Norway.

From 1990 to 1995, emissions from non–Annex I parties increased by ~25% (*2*). Although emissions will probably not continue to increase at this pace, an increase of only ~4% per year would mean that in 2010 Annex I and non–Annex I parties would each contribute ~50% to total emissions of about 8.3 gigatons (Gt) of carbon, if the Annex I parties comply with the Kyoto agreements.

World population is expected to reach about 7 billion in 2010, of which almost 80% are expected to be living in developing countries. Emissions by non–Annex I parties would by then be 0.74 metric tons (t) of carbon per capita versus 0.51 t of carbon today. On the other hand, emissions in Annex I countries would have decreased from about 3.05 today to 2.85 t of carbon per capita; that is, emissions per capita in these

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countries would still be almost four times those of non–Annex I parties.

Atmospheric CO_2 Levels

Even with the goals set in Kyoto, I estimate that the accumulated emissions of CO_2 from 1990 to 2010 would amount to ~140 Gt of carbon, which would increase the atmospheric concentration of CO_2 by ~29 ppmv to ~382 ppmv (3). Annex I countries would have contributed ~57% to this increase and the non–Annex I countries ~43%.

If Annex I parties did not reduce their emissions but rather increased them by ~20% by 2010, an additional 4 to 6 Gt of carbon would be emitted. The concentration of CO_2 in the atmosphere in 2010 would then be 1 to 1.5 ppmv higher than it would be if the restrictions on emissions prescribed in the Kyoto Protocol were accepted. Because of the long residence time of CO_2 in the atmosphere, even a modest reduction in the rate of increase of atmospheric CO_2 would be of long-term significance. It would still be an important first step and be increasingly beneficial during future decades, even if a reduction would be far from what is required to reach the goal of stabilizing the concentration of CO_2 in the atmosphere.

The inertia of the climate system was not appreciated fully by the delegates in Kyoto. It therefore seems likely that another international effort will be required well before 2010 to consider whether further measures are warranted. The IPCC third assessment will be available early in 2001.

Sources and Sinks

Atmospheric CO_2 concentrations change not only as a result of burning fossil fuels. The terrestrial biosphere serves as an important source or sink for CO_2, as well as for methane and nitrous oxide. Human activities disturb these exchanges, and the convention agreed that parties should report on the effects of anthropogenic interference of this kind. How to account for such terrestrial sinks in the context of the national commitments was discussed extensively in Kyoto, particularly with regard to the role of forests.

The IPCC has developed guidelines to establish a common base for determination of changes in sources and sinks, but these were not designed to serve as a legal basis for compliance. Although emissions from the use of fossil fuels can be determined adequately, changes in carbon inventories in the terrestrial biosphere, including soils, cannot yet be assessed very well.

It is thus difficult to separate anthropogenically induced changes in sources and sinks from natural changes. Annex I parties use various methods to estimate these changes. The differences among these methods have not been assessed. The carbon content of soils can change in the opposite direction to changes in above-ground biomass. Regrowth after harvesting is influenced by changing soil conditions and fertilization. The delayed effects of biogenic processes should be accounted for, but data are lacking and uncertainties are large.

The protocol now includes a statement that "... net changes in greenhouse gas emissions from sources and removals by sinks resulting from direct human-induced land use change and forestry activities, limited to afforestation, reforestation, and deforestation since 1990, measured as verifiable changes of stocks in each commitment period shall be used to meet the commitments in this Article (No. 3) of each Party included in Annex I." The protocol refers to work by the IPCC to resolve this issue before the next conference of parties. It is, however, not clear how to devise satisfactory methods to achieve what is envisaged in the protocol.

Tradable Emission Permits

Although it is important to set targets and timetables, the fundamental problem of climate change cannot be settled that simply. The supply of energy is a fundamental requirement for development, even though less may be needed than has been used in the past by Annex I countries and much better efficiency can be achieved.

The convention prescribes "... that policies and measures to deal with the climate change should be cost-effective so as to ensure global benefits at the lowest possible cost." Both regulatory measures and economic instruments can be used, but the IPCC has emphasized that economic instruments such as emissions trading and carbon taxes can substantially reduce the costs of achieving a given target. Such policies could raise substantial revenues, and a proper distribution of such revenues could dramatically affect the cost of mitigation.

Emissions of CO_2 (Mt C per year)

Party	1990	1995
European Union	949	936
OECD, except EU	2086	2254
Countries in transition	1311	925
Non–Annex I parties	1774	2225

Table 2. Emissions of CO_2.

The Kyoto conference is a first step toward the introduction of economical instruments to achieve specific targets. Thus Article 6 of the protocol stipulates: "For the purpose of meeting its commitments under Article 3, any Party included in Annex I may transfer to, or acquire from, any other such Party emission reduction units resulting from projects aimed at reducing anthropogenic emissions by sources or enhancing anthropogenic removals by sinks of greenhouse gases in any sector of the economy ..." However, several conditions will need to be fulfilled to achieve mutual agreement between the parties concerned. Also, "... principles, modalities, rules and guidelines, in particular for verification, reporting and accountability for emissions trading" will have to be defined by the parties of the convention.

The emission limitations and reduction requirements that were agreed on in Kyoto as targets for 2010 (Table 1) represent an invitation to trade reduction units, particularly between the OECD countries and countries in economic transition. Essentially no further reductions in total emissions by Annex I countries beyond what has already been achieved are stipulated in the Kyoto protocol. The protocol therefore can be seen as an attempt to induce Annex I countries to find efficient ways to reduce emissions later. This signal hopefully should be clear enough to induce industry to take appropriate preparatory steps. It may also set the stage for gradually creating a global market for trading emission permits. Obviously, much care must then be exercised to properly recognize the major differences among countries of the world. This is by no means an easy task.

The Kyoto conference did not achieve much with regard to limiting the buildup of greenhouse gases in the atmosphere. If no further steps are taken during the next 10 years, CO_2 will increase in the atmosphere during the first decade of the next century essentially as it has done during the past few decades. Only if the new cooperation among countries succeeds will the Kyoto conference represent a step toward the ultimate objective of the convention: "... to achieve ... stabilization of greenhouse gas concentrations in the atmosphere at a level that would prevent dangerous anthropogenic interference with the climate system."

References and Notes

1. The IPCC Second Assessment Report (SAR) (Cambridge Univ. Press, Cambridge, 1996) includes *Climate Change 1995—The Science of Climate Change* (report of IPCC Working Group I); *Climate Change 1995—Scientific-Technical Analyses of Impacts, Adaptation and Mitigation of Climate Change* (report of IPCC Working Group II); *Climate Change 1995—The Economic and Social Dimensions of Climate Change* (report of IPCC working Group III). Also see *The IPCC Second Assessment, Synthesis of Scientific-Technical Information Relevant to Interpreting Article 2 of the UN Framework Convention on Climate Change* (World Meteorological Organization, Geneva, 1996).
2. International Energy Agency, *CO_2 Emissions from Fuel Combustion* (OECD, Paris, 1997).
3. IPCC, *IPCC Tech. Pap. 4* (World Meteorological Organization, Geneva, 1996).
4. World Energy Council, Report No. 7, London, 1997.